

Original Article

Factors Affecting Successful Creation of Arterio-venous Fistula for Hemodialysis

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Abstract

The preferred vascular access method for efficient hemodialysis is the arterio-venous fistula (AVF). There is a rising trend in AVF establishment conducted by nephrologists, aiming to alleviate the workload of vascular surgeons and expedite the prompt care of individuals afflicted with end-stage renal disease (ESRD). This descriptive observational study was conducted at the Department of Vascular Surgery, Ibrahim Cardiac Hospital and Research Institute during the period of June 2017 to July 2022. During the data collection period 1700 patients sought care in the Department for arterio-venous fistula creation, among them complete data of 1103 patients were included in this study. Majority of chronic kidney disease (CKD) patients were referred from the Department of Nephrology, BIRDEM for AVF creation in the mentioned timeline. Data were collected pre-designed data collection sheet and data were analyzed using Statistical Package for Social Sciences (SPSS) version- 25. This study shows that most of the patients (80.8%) were in ages 30 - 59 years and more than two-third (67.6%) of them were male; male-female ratio was 2:1. Diabetes mellitus (DM) was detected in nearly half of the patients (47.2%) and more than two-third (67.2%) of them were suffering from hypertension (HTN). Higher failure rate (73.3%) of AVF creation among patients of age group 30-59 years, which was significant. Failure rate for male patients was 57% and female patients was 43%. The AVF creation failure rates were 100% for

patients with hypertension and for diabetes patients was 60.5%. Complications were found in 15.2% of patients. Post-operative edema and hematoma formation were more common (3.2% and 3.5%, respectively) in comparison to other complications. Among the complicated cases, 7 patients (4.2%) required intervention to correct stealing syndrome and AVF salvage was attempted in 43 cases (25.6%); medical management was pursued in 32(19.0%) cases. Majority (51.2%) of cases who were experiencing complications required AVF ligation. This research demonstrates that several significant clinical factors influence the successful establishment of an arterio-venous fistula (AVF) for hemodialysis factors include advanced age, being male, having diabetes (DM) and hypertension (HTN), having a history of Maintenance Hemodialysis (MHD) prior to AVF creation, choosing the wrist or arm as the AVF site, utilizing specific veins (cephalic and basilic) and specific arteries (radial and brachial).

Keywords: Arterio venous fistula (AVF), end stage renal disease (ESRD), creatinine clearance rate (CCR), maintenance hemodialysis (MHD)

INTRODUCTION

The incidence of chronic kidney diseases is increasing at a galloping rate, particularly with the expanding number of hypertension and diabetes mellitus. Along with higher rates of chronic kidney diseases, End Stage Renal Diseases (ESRD) are also escalating, which requires maintenance hemodialysis. To avail hemodialysis among ESRD patients, successful creation of Arterio-venous fistula (AVF) is essential. In last few years, a good number of AVF creation surgery was performed at Department of Vascular Surgery, Ibrahim Cardiac Hospital & Research Institute. Successful AVF creation depends upon a number of factors. Present study will outline the effects of numerous variables on the results of AVF creation in Bangladeshi population as well as the important parameters to take into account. The aim of this study is to review the experience of creating AVF and to assess its success rate and common complications.

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Chronic kidney disease (CKD) is the 16th leading cause of demise worldwide identified as a major public health problem globally and the prevalence is projected to increase continually. In Asia, approximately 434.3 million people had End-Stage Renal Disease (ESRD) that is about 60% of the global population; who are seeking medical attention.¹ According to the National Journal Database, until December 2019, the overall prevalence of CKD in Bangladeshi people was of 22.48%, which was higher than the global prevalence of CKD.² Chronic kidney disease includes five stages of kidney damage, from mild kidney dysfunction to complete failure. Generally, a person with CKD stage 5 is considered as End stage renal disease, who eventually needs hemodialysis.³ To serve this huge population, creation of AVF for hemodialysis is mandatory as the opportunities for kidney replacement surgery is limited in our country.⁴ Being a specialized center, at Vascular Surgery Department, Ibrahim Cardiac Hospital & Research Institute thousands of AVF have been created for advanced stage CKD patients in last five years.

A reliable and smoothly operating vascular access for hemodialysis (HD) especially the Arterio-venous fistula (AVF) is the lifeline for an ESRD patient. Failure to create a well-functioning AVF is an obstacle for hemodialysis that will be declining the life expectancy of the huge population suffering from ESRD. From this study multiple variables can be analyzed related to a successful AVF creation and unfavorable factors adversely affecting the outcome can be overcome.⁵

Previously different researches has been done in the different corner of the world. In the Asian context, several studies on outcomes of AVF creation among hemodialysis patients has been under taken at India, Japan, Iran etc. but the study population were not big enough to reflect the huge population.⁵⁻⁸ Again the studies that were done earlier in Bangladeshi context were of limited sample size. So the outcomes that arrived from those studies cannot be generalized. The study has been conducted to analyze data from larger population of Bangladesh, that will be reflecting the common demographic characteristics, beneficial and the contrary variables of AVF creation for hemodialysis among the Bangladeshi population. On the other hand this research will enrich the epidemiological background of ESRD patients seeking for AVF creation,

in our subcontinent. So the present study was under taken to determine the factors responsible for successful outcome of AVF creation.

MATERIALS AND METHODS

This research was designed as a descriptive observational study derived from the Department of Vascular Surgery, Ibrahim Cardiac Hospital and Research Institute. The Data used in this study was obtained from the time period June, 2017 to July, 2022. During that period about 1700 patients visited Dept. of Vascular surgery for arterio-venous fistula creation, among them complete data of 1103 patients were included in our study. Majority of chronic kidney disease (CKD) patients were referred to us from the Department of Nephrology, BIRDEM for AVF creation in the mentioned timeline (June, 2017 to July, 2022). These patients were of both sexes (male or female), of any age. Bangladeshi individual may or may not be undergoing maintenance hemodialysis. Follow-up details were obtained during the Out Patient Department (OPD) visits. The data extracted from hospital records included the patient's demographic details, comorbidities, site and type of AVF, operative details, patency and fistula-related complications.

Data analysis was done projecting multiple variables, that are age group, gender, type of AVF created, site of AVF, artery and vein used, hemodialysis prior to AVF creation, the co-morbidities like DM, HTN and the relative complications along with their corrective surgery.

Statistical analysis

Data were collected by pre-designed data collection sheet. Complete history and documentations were reliable enough to perform the Data Collection. Then the Data was analyzed by using SPSS for windows version 25. Descriptive statistics were expressed in frequency, percentage, arithmetic mean. For inferential statistics, chi-square test was performed to explore the association between categorical variables. Multivariable logistic regression analysis was carried out in order to determine the relationship between various components. The confidence interval was set at 95% and the significance level was set at less than 0.05 (p0.05).

RESULTS

Table I contains the baseline characteristics of the patients, these are- 80.8% were age of 30 to 59 years and 67.6%

were male. Diabetes Mellitus (DM) was observed in 47.2%, hypertension in 67.2%. Here 82.7% had undergone maintenance hemodialysis (MHD) before arterio-venous fistula creation. Jugular access was observed in 34.7% of cases and femoral access in 48% cases. Notably, radio-cephalic fistulas at the wrist accounted for 47.9% of cases, and brachio-cephalic fistulas constituted 35.1%.

Table- I: Baseline Characteristics of the Patients (n=1103)

Characteristics	Frequency	Percentage
Age in years		
<30	74	6.7
30-59	891	80.8
>60	138	12.5
Mean ±SD	47.49±11.61	
Sex		
Male	746	67.6
Female	357	32.4
DM	521	47.2
HTN	741	67.2
MHD (before AVF creation)	912	82.7
Type of vascular access before AVF		
Jugular	383	34.7
Femoral	529	48.0
Types of AVF		
Anatomical snuff box fistula	11	1.0
Radio-cephalic fistula at wrist	528	47.9
Radio-cephalic fistula at mid-forearm	23	2.1
Brachio-cephalic fistula	387	35.1
Brachio-basilic transposition fistula	141	12.8
Brachio-axillary translocation fistula	02	0.2
PTFE graft fistula	07	0.6
Ulnar-Basilic fistula	01	0.1
Ulnar-Ulnar U loop fistula (PTFE Graft)	02	0.2
PTA to GSV fistula	01	0.1

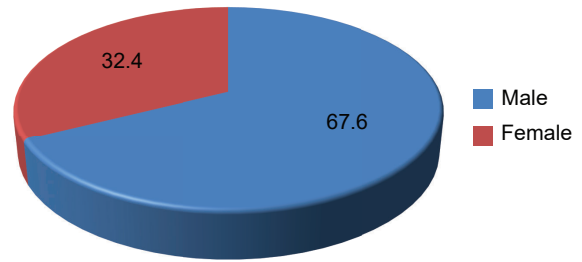


Figure- 1: Sex distribution of the patents

Figure 1 shows 67.6% were male and 32.4% were female.

Table II represents the anatomical details of the study subjects who underwent AVF creation; 48.8% and 49.0% of AVFs were created at the wrist and arm respectively. Veins were used the cephalic vein (74.5%), radial artery (51%) and brachial artery (48.7%).

Table- II: Anatomical details of the study subjects who underwent AVF creation (n=1103).

	Frequency	Percentage
Site of AVF		
Wrist	539	48.8
Forearm	23	2.1
Arm	540	49.0
Lower limb	01	0.1
Vein		
Cephalic vein	822	74.5
Ante Cubital vein	127	11.5
Basilic vein	144	13.1
Great saphenous vein	01	0.1
PTFE Graft	09	0.8
Artery		
Radial artery	562	51.0
Brachial artery	537	48.7
Ulnar Artery	03	0.3
Posterior tibial artery	01	0.1

Table III describes the factors associated with AVF creation using Chi-square test; the failure rate of patients was 73.3% in age group 30-59 years and it was significant. Failure rate among males were 57%. Failure rate of diabetic patients was 60.5% and HTN 100%. Patients on maintenance hemodialysis were 100% failure rate and arm site of AVF was failure rate 53.5%. Cephalic vein was failure rate 57% and radial artery was 74.4%.

Table- III: Factors associated with AVF creation using Chi-square test (n=384)

Factors or the Patient's Characteristics		Outcome		P value
		Success (n=1017)	Failure (n=86)	
Age	<30 (74)	74(7.3%)	0(00)	0.001
	30-59 (863)	828(81.4%)	63(73.3%)	
	>60 (166)	115(11.3%)	23(26.7%)	
Sex	Male	697(68.5%)	49(57%)	0.028
	Female	320(31.5%)	37(43%)	
DM	Yes	469(61.1%)	52(60.5%)	0.010
	No	548(53.9%)	34(39.5%)	
HTN	Yes	655(64.4%)	86(100)	0.001
	No	362(35.6%)	0(00)	
MHD (before AVF creation)	Yes	826(81.2%)	86(100)	0.001
	No	191(18.8%)	0(00)	
Site of AVF	Wrist	501(49.3%)	38(44.2%)	0.821
	Forearm	21(2.1%)	2(2.3%)	
	Arm	494(48.6%)	46(53.5%)	
	Lower limb	1(0.1%)	0(00)	
Vein	Cephalic vein	773(76%)	49(57%)	0.001
	Ante Cubital vein	112(11%)	15(17.4%)	
	Basilic vein	122(12%)	22(25.6%)	
	Great saphenous vein	10(1%)	0(00)	
Artery	Radial artery	498(49%)	64(74.4%)	0.001
	Brachial artery	515(50.6%)	22(25.6%)	
	Ulnar Artery	3(0.3%)	0(00)	
	Post. tibial artery	1(0.1%)	0(00)	

Table IV states the predictive factors of successful outcomes after arterio-venous fistula creation; here age, gender, DM, HTN, artery and vein was a significant predictor of AVF success (P=0.001, 0.029, 0.011, 0.001 and 0.004)

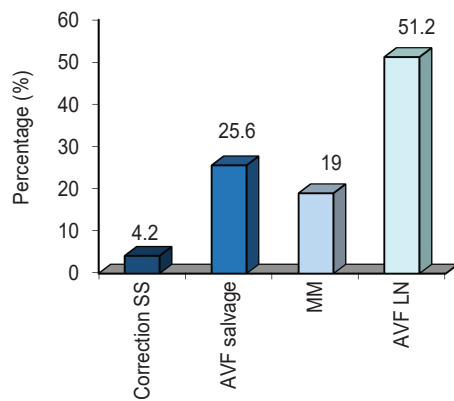
Table- IV: Predictive factors of successful outcomes after arterio-venous fistula creation

Variables	Coefficient	Standard error	P-value	Odds Ratio
Age	1.052	0.263	0.001	2.863
Gender	0.498	0.228	0.029	1.645
DM	0.581	0.229	0.011	1.560
HTN	0.594	0.241	0.016	1.551
Site of AVF	0.166	0.210	0.428	0.847
Artery	0.902	0.221	0.001	2.464
Vein	0.378	0.133	0.004	1.459

Table V shows the summary of the complications in the study. A total of 15.2% patients had complications; among them post-operative edema and hematoma formation were (3.2% and 3.5%, respectively).

Table-V: Summary of the complications in the study (n=1103)

Complications	Frequency	Percentage
Post-operative Bleeding	24	2.1
Post-operative Edema	35	3.2
Hematoma Formation	39	3.5
Pseudoaneurysm Formation	23	2.1
Thrombosis	29	2.6
Post-operative cellulitic changes	11	1.1
Stealing Syndrome	07	0.6
No complication	935	84.8



NB: SS=Stealing Syndrome, MM=Medical management, LN= Ligation needed

Figure- 2: Summary of outcome of the complicated Cases in this study (n=168)

Figure 2 depicts the summary of outcome of the complicated cases in this study. Among the complicated cases, 7 patients (4.2%) required intervention to correct stealing syndrome and 43 cases (25.6%) AVF salvage was attempted, medical management was pursued in 32 cases (19.0%) and majority of cases experiencing complications (51.2%), AVF ligation was required.

DISCUSSION

The procedure of arteriovenous fistula holds significant importance for vascular surgeons. As the global demand for hemodialysis increases among patients with end-stage renal disease (ESRD), arteriovenous fistulas (AVF) have gained

prominence as the preferred vascular access method due to their extended functionality, increased resilience, and lowered infection risk.⁹

This study shows the majority of patients constituting 80.8% were the ages of 30 to 59 years. A notable proportion, 12.5%, were aged 60 or older, while 6.7% were under the age of 30. This findings consistent with several previous studies.³⁻⁷

As reported in the study by Sichona et al.¹⁰ the research identified patients within the higher age bracket of 50 to 59 years. These results are further supported by earlier investigations conducted in Europe, which also indicated that advanced age was associated with older patients, typically those aged over 65 years.¹¹

The gender distribution observed in this study, where males constituted 67.6% and females 32.4%, mirrors the gender imbalance frequently documented in kidney disease populations across various studies.⁴⁻⁹ This gender disparity has sparked investigations into whether hormonal differences, genetic factors, or disparities in healthcare-seeking behavior contribute to the observed pattern. Also found that the outcome among males was more successful (p=0.001). This findings are well agreement with other studies.⁶⁻¹²

This study shows patients with hypertension and diabetes were more likely to have AVF failure rate. The findings of this study consisted with previous studies.⁷⁻¹² Other studies, on the other hand, found that hypertension was not a significant risk factor for AVF creation. Another study reported diabetes represents an ever-growing cause of ESRD.⁵ In the past, even though diabetes was considered a risk factor for Arterio-venous fistula non-maturation, several studies have reported successful outcomes in diabetic patients.¹²⁻¹⁴ Sedlacek et al. concluded that diabetes didn't independently contribute to AVF non-maturation, and its presence didn't impact the success of AVF creation.¹⁵ Allon et al. similarly found that both diabetes and age didn't affect AVF maturation outcomes, although they were both significantly linked to increased intimal hyperplasia.¹³ In a similar vein, Farber et al. discovered that diabetes wasn't connected to early thrombosis.¹⁶ Conversely, Salmela et al. noted that diabetes mellitus, female gender, and thrombophilia were associated with decreased primary fistula patency rates.¹²

This study shows MHD (before AVF creation), wrist site of AVF, arm site of AVF, cephalic vein, basilic vein, radial artery and brachial artery were more likely to have AVF

failure rate. This study's findings are consistent with prior research, which found that MHD (before AVF creation), wrist site of AVF, arm site of AVF, cephalic vein, basilic vein, radial artery and brachial artery had a greater main failure rate arterio-venous fistula for hemodialysis.⁸⁻¹² Previous studies examined MHD, wrist site of AVF, arm site of AVF, cephalic vein, basilic vein, radial artery and brachial artery main factor of affecting successful creation of Arterio-venous fistula for Hemodialysis.^{14,15} Prospective observational study results have shown that wrist site of AVF, arm site of AVF, cephalic vein, basilic vein, radial artery and brachial artery linked to a higher factor of Arterio-venous fistula for Hemodialysis.¹⁷ A prospective study by V. Wong et al assessed the radial arteries and cephalic veins found that fistula failure was associated with cephalic vein and radial artery.¹⁸

This study shows Hematoma formation was the common complication present i.e. in 39 (3.35%) then post-operative edema (3.2%), thrombosis (2.6%), pseudoaneurysm formation (2.1%) and post-operative bleeding 2.1%). Similar studies Moloti reported out of the total 15 unsuccessful AV fistula, thrombosis was the major complication present in 10 (22.22%) AVF, least complication was wound infection and vessel blowout, out of which the vessel blowout was a result of trauma and the patient had sustained.¹⁹ In a study by Qing Y et al. conducted in Shanghai First People's Hospital affiliated to Jiaotong University reported that the most frequent complication seen following creation of an AV fistula was thrombosis (13.86%).²⁹ Previous studies examined complications related to AVF construction and reported venous thrombosis rates as high as 58%, with a susceptibility for thrombosis in the cephalic and basilic veins.^{20, 21}

This study shows that AVF ligation needed emerges as the most prevalent complication among the cases, occurring in 51.2% of the total cases. On the other hand, the complication with the lowest frequency and percentage is the correction of stealing syndrome which appeared in only 4.2% of the cases. The category of AVF salvage is notable as well, appearing in 25.6% of the cases. The medical management category, accounting for 19.0% of cases, raises questions about the nature of complications that necessitated non-surgical interventions. Similar study Moloti et al.¹⁹ reported out of the 10 AVF complicated by thrombosis, 6 AVF were treated with surgical thrombectomy.

LIMITATION

- Inadequate data regarding arterial & venous diameter.
- Certain parameters like clinical laboratory parameters were not included and hence their role or bias could not be determined.

CONCLUSION

This research presents findings that highlight the significance of certain clinical factors in the successful establishment of arteriovenous fistulas (AVFs) for hemodialysis. These factors encompass older age, male gender, diabetes (DM), hypertension (HTN), pre-existing heart disease (MHD) prior to AVF creation, AVF placement at the wrist or arm sites, utilization of specific veins (cephalic and basilic), as well as particular arteries (radial and brachial). Additionally, the study underscores the necessity for meticulous planning by a vascular surgeon and the thoughtful selection of patients in collaboration with nephrologists when considering AVF creation. This approach is advocated to enhance the positive outcomes of AV access, thus promoting greater utilization of AV fistulas as the primary mode of access for hemodialysis in end-stage renal disease cases. To facilitate this, the study supports the establishment of a specialized renal access clinic. This clinic would serve as a dedicated platform for comprehensive AVF creation planning, incorporating pre-operative Doppler scans and offering the evaluation of challenging access scenarios before the surgical procedure.

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